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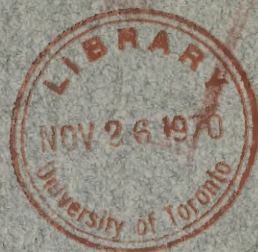
VIRGINIA GEOLOGICAL SURVEY

UNIVERSITY OF VIRGINIA

THOMAS LEONARD WATSON, PH. D.

DIRECTOR

Bulletin No. XV-A



Tin Deposits Near Irish Creek, Virginia

BY

HENRY G. FERGUSON

PREPARED IN CO-OPERATION WITH THE
UNITED STATES GEOLOGICAL SURVEY

CHARLOTTESVILLE
UNIVERSITY OF VIRGINIA
1918

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LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, February, 1918.

*Governor Westmoreland Davis, Chairman, and Members of the State
Geological Commission:*

GENTLEMEN:—I have the honor to transmit to you herewith, and to recommend for publication as Bulletin XV-A of the Virginia Geological Survey Series of Reports, a manuscript and illustrations of a report on "Tin Deposits Near Irish Creek, Virginia," by Henry G. Ferguson, of the United States Geological Survey, prepared in coöperation with the Virginia Geological Survey.

The tin deposits of the Irish Creek district in Rockbridge County, Virginia, are among the most promising in the United States. Since the United States is entirely dependent upon foreign countries for its supply of tin, and since the metal is urgently needed as a war-time necessity, it is hoped that this publication will serve to direct attention to the development of the tin deposits in this important district.

Respectfully submitted,

THOMAS L. WATSON,
Director.



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TIN DEPOSITS NEAR IRISH CREEK, VIRGINIA

By HENRY G. FERGUSON.

LOCATION OF THE DEPOSITS.

The United States is entirely dependent upon foreign countries for its supply of tin. As this metal is a war-time necessity and as a domestic source of supply is urgently needed, all known deposits of tin ore (cassiterite) in the United States have been recently examined by members of the U. S. Geological Survey. One of the most promising of these deposits is in the



FIG. 1.—Map of a portion of Virginia, showing the location of the Irish Creek tin deposits, Rockbridge County.

Irish Creek district in Virginia. A short general description of this deposit, which was examined by the writer in May, 1917, is here presented in the hope that it may be of value if another attempt is made to mine tin ore at this place.

It has long been known that cassiterite-bearing veins outcrop near the summit of the Blue Ridge, at the head of Irish Creek, in Rockbridge County, Virginia, but for the last twenty-five years no work has been done on these veins and little was to be seen of the workings themselves. The writer is indebted to Mr. A. G. White, Secretary of the War Minerals Committee, for permission to consult reports on the property, made in 1893, by

Mr. A. C. Ledoux and Professor W. O. Crosby; and to Mr. Moses Joy, of New Haven, Conn., for several interesting specimens of ore from the prospects. Mr. F. L. Hess made a short visit to this district in 1913, and has kindly placed his notes and specimens at the disposal of the writer.

The Irish Creek tin district is in an isolated part of the Blue Ridge of Virginia. The nearest post-offices are Irish Creek, which is a short distance west of the tin deposits, and Montebello, in Nelson County, a few miles east of them. The district can be reached by roads that are passable except in very bad weather. The old mine may be reached from Arrington, on the Southern Railway, by a drive of 29 miles, or from Vesuvius, on the Norfolk and Western Railroad, by a drive of 12 miles. Accommodations may be had at the house of Mr. Sam Cash, about a mile west of the mine. In May, 1917, a logging railroad was under construction from the mouth of Irish Creek to a point near Irish Creek post-office.

The Blue Ridge in this vicinity, particularly near the crest of the ridge and a short distance to the east and west, consists of irregular hills and ridges. The highest points in the immediate vicinity of the district reach altitudes exceeding 3,500 feet above sea-level, and the bed of Irish Creek, near Irish Creek post-office, is slightly below 2,000 feet. The valley of Irish Creek is more open and less mountainous than the neighboring valleys to the north and south. Millstone Hill, a long, steep ridge capped with quartzite, overlooks the valley from the north. Small stretches of level land along the stream and parts of the steep hillsides are under cultivation, but most of the hilly portions are densely wooded. Though the areas underlain by igneous rocks have been deeply eroded, the rocks are greatly weathered so that outcrops of fresh rock are found at few places except in the streams.

HISTORY OF MINING.

Cassiterite from the Irish Creek region was first identified by Professor Armstrong, of Washington College,^a Lexington, Va., in 1846,^b and it is reported that some prospecting was done in the region during the next few years, but afterward the existence of the ore seems to have been forgotten. The ore was rediscovered in 1882 by Mrs. Martha D. Cash, prospecting began in 1883, and the Virginia Tin Mining and Manufacturing Company was organized in 1884. By this time a tunnel 80 feet long had been driven on the vein.^c The Lexington Tin Company appears to have operated in the

^a Washington and Lee University.

^b Ulke, Titus, *Min. Res. of the United States*, 1893, p. 180, 1894.

^c Hotchkiss, J., *Virginia Minerals for the New Orleans Exposition*. The Virginias, vol. 5, p. 196, 1884.

district in 1885. Work continued until 1886, when litigation caused the closing of the mines. As far as known no shipments were made, but about 290 tons of ore averaging about 3.3 per cent of tin had been mined.^a In 1889 some Boston capitalists obtained an option on the mine and built a mill said to have cost \$50,000. According to Ulke,^b 2,400 pounds of concentrates containing 43 per cent of metallic tin was shipped. The company was unable to obtain an extension of its option and became involved in litigation as to land titles, so work was abandoned in 1893. Since that time no systematic attempt has been made to work the deposit. It is said that a small amount of tin has been smelted in blacksmith forges near the deposit. The long period of idleness from 1893 to the present time appears to be due to uncertainty as to title to the property rather than to lack of confidence in the value of the deposits.

GEOLOGY.

The rocks of the district are mainly granodiorite, granite, and granitic gneisses, all probably of pre-Cambrian age, Cambrian sedimentary rocks, and later diabase dikes. The distribution of each type is shown approximately on the accompanying map (Fig. 2). The Cambrian sedimentary rocks outcrop along the crest of Millstone Ridge north of Irish Creek and along the creek itself from a point about 4 miles below Irish Creek post-office to the Shenandoah Valley, and they cap the hills on the south side of the creek, southeast of Irish Gap. Along Millstone Ridge the sedimentary rocks consist of purple slate and quartzitic sandstone and grit. Here the dips are steep to the south and southeast, that is, toward the granite, so that along the ridge the contact between the sediments and the pre-Cambrian rocks is perhaps a fault plane. In the lower part of Irish Creek valley, however, particularly along the road to Irish Gap, the contact is one of erosion, and the sediments, here largely arkose, directly overlie the pre-Cambrian gneiss. Small isolated patches of slate and arkose were found in the eastern part of the area. These appear to represent remnants of the original sedimentary cover that have been preserved by folding.

The older crystalline rocks include gneiss of various types, granite, granodiorite, and nelsonite. The country rock of the tin veins is a granodiorite, which outcrops about the headwaters of Irish Creek. It is apparently younger than the surrounding gneiss, for it shows no gneissoid structure, but its relations to the granite and nelsonite are not clear. The

^a Watson, T. L., *Mineral Resources of Virginia*, p. 570, 1907.

^b Loc. cit., p. 181.

rock is coarse-grained, dark green where fresh, and presents a peculiar mottled appearance, due to the irregular distribution of the hypersthene it contains. The average size of grain is about one centimeter, but large feldspar phenocrysts occur. The essential constituents of the rock are quartz, plagioclase, and orthoclase, a small amount of microcline feldspar, and hypersthene. The amount of quartz is extremely variable from place to place, but is everywhere less than that of the feldspar. It has a peculiar milky, almost opalescent, appearance in the hand specimen. The plagioclase, which is about andesine in composition, equals or exceeds the orthoclase in volume. In places the quartz occurs in poikilitic intergrowth with the orthoclase and microcline. The principal ferromagnesian mineral is hypersthene, an unusual constituent of rock of this type. Small amounts of hornblende are seen in some specimens, and rarely a little biotite. An opaque, metallic mineral, which occurs in the rock in considerable quantity, is probably ilmenite rather than magnetite. Apatite is a rare accessory. Secondary titanite in places surrounds the grains of ilmenite, and in some specimens the hypersthene has been altered to fibrous hornblende. Chlorite has formed as an alteration product of the hornblende and hypersthene. Over parts of the area occupied by the granodiorite considerable secondary epidotization has taken place. All stages of alteration may be observed. Most commonly the ferromagnesian minerals are completely replaced and the plagioclase is attacked to a greater degree than the orthoclase, producing the so-called unakite.^a In a few places the feldspar has also been almost completely replaced, producing the rock called epidosite by Phalen.^b This epidotization was not observed near the ore bodies, and is believed to be the result of later regional metamorphism rather than of the ore-forming processes.

The approximate boundaries of the granodiorite in the Irish Creek region are shown on the accompanying map, but the rock appears to be widely distributed throughout the Blue Ridge region^c in Virginia. The granodiorite and related rocks have been described in detail by Watson and Cline.^d No direct evidence of the age of the granodiorite was found, but it is probably pre-Cambrian. The granite which accompanies the Carolina tin deposits is, however, regarded by Keith and Sterrett as late Carboniferous.^e

^a Phalen, W. C.: A new occurrence of unakite; preliminary paper. Smithsonian Miscellaneous Collections, vol. 45, pp. 306-316, 1903.

^b Loc. cit., p. 314.

^c Watson, T. L., and Cline, J. H.: Hypersthene syenite and related rocks of the Blue Ridge region, Virginia. Bull. Geol. Soc. Am., vol. 27, pp. 193-234, 1916.

^d Watson, T. L., and Cline, J. H.: Ibidem, pp. 193-234, 1916.

^e Keith, A. C., and Sterrett, D. B.: Tin in the Kings Mountain District, North and South Carolina, U. S. Geol. Survey Bull. 660-D, 1917.

Dikes of very fine-grained aplite cut the granodiorite in the vicinity of the tin deposits. The rock of these dikes has an average size of grain of about 0.1 millimeter and consists essentially of quartz, orthoclase, microcline, and albite. It contains also small amounts of muscovite and fluorite, both apparently original constituents. Fragments of an albitic granite, which consists essentially of quartz, orthoclase, albite, and biotite, and is of much coarser grain than the aplite, were found on the dump near the mill. Hydrothermal action has introduced muscovite, fluorite, and a carbonate, probably siderite. The field relations of this rock are unknown, but the specimen examined probably came from a dike that cuts the granodiorite.

A fine-grained orthoclase granite is found in the eastern part of the area studied. This rock consists principally of quartz, orthoclase, and a little biotite, though some specimens contain also a little plagioclase. This granite in places is gneissic and appears to grade into the surrounding gneiss. Probably it is older than the hypersthene granodiorite.

The gneiss that occupies a large part of the area studied is distinctly granitic and most of it consists essentially of quartz and orthoclase, though it includes here and there small amounts of chlorite, which apparently takes the place of the original biotite. More basic types, in which hornblende and biotite occur in considerable amount, are found, but are less common.

Two masses of nelsonite,^a a fine-grained granular rock consisting essentially of nearly equal amounts of ilmenite and apatite, were noted, and are believed to be dikes intruded into the gneiss.

Small dikes of a much-altered diabase occur at many places, particularly in the area of granodiorite. These are probably later than the other igneous rocks of the region, for at one place a diabase dike appears to cut a quartz vein in the granodiorite.

ORE DEPOSITS.

Cassiterite is the tin-bearing mineral of the deposits. It is found in quartz veins that cut the hypersthene granodiorite and in the adjacent altered granodiorite. In addition to quartz and cassiterite the deposits contain arsenopyrite, pyrite, siderite, wolframite, scheelite, muscovite, fluorite, and beryl.

Most of the cassiterite shows crystal faces, though no perfect crystals were seen. It is said that large masses of crystals, lining vugs, were occa-

^a See Bull. No. III-A, Va. Geol. Survey, 1913, for a full discussion of nelsonite and its varieties in the Nelson County districts a short distance to the east and south-east of the Irish Creek tin area.

sionally found in the old workings. Most of the cassiterite is brown and its luster is adamantine to submetallic. A few specimens are gray or nearly white. Under the microscope the mineral shows brown and gray zones and in places is twinned. One specimen shows a distinct parting, the crystallographic direction of which was not determined. As far as observed, the cassiterite everywhere occurs close to the walls of the vein, and, according to the reports of persons familiar with the old workings, this mode of occurrence was universal. Apparently cassiterite was the earliest mineral to crystallize, for its crystal faces lie in contact with the vein quartz. It is cut by minute veinlets, nowhere over 0.1 millimeter wide. In one specimen these veinlets appear to consist of chlorite containing minute specks of a metallic mineral, possibly wolframite, and in another they consist of tourmaline, quartz, and a little muscovite. These veinlets end abruptly at the boundary of the cassiterite and the quartz. In the altered rock next to the veins, cassiterite occurs in minute specks, and usually in small quantity, although it is reported that in places the altered wall-rock contains workable tin for a distance of several feet from the vein.

The following analysis of cassiterite was made by Campbell in 1883:^a

Analysis of Cassiterite from Irish Creek, Va.

	<i>Per cent</i>
Metallic tin	63.583
Metallic iron	1.680
Silica	8.415
Sulphur	0.066
Arsenic	0.301
Titanium	distinct trace

A more complete analysis, evidently of purer material, was made by Brown^b in 1885. The tantalic acid is doubtful.

Analysis of Cassiterite from Irish Creek, Va.

	<i>Per cent</i>
Tin oxide (SnO ₂)	94.895
Silica (SiO ₂)	.760
Tantalum oxide (Ta ₂ O ₅)	.237
Ferric oxide (Fe ₂ O ₃)	3.418
Lime (CaO)	.244
Magnesia (MgO)	.027
Ignition	.385
	99.966

^a Campbell, Harry D.: Tin Ore in the Blue Ridge in Virginia, The Virginias, vol. 4, p. 151, 1883.

^b Brown, W. G.: On Cassiterite from Irish Creek, Rockbridge County, Virginia, Am. Chem. Jour., vol. 6, pp. 185-187, 1885.

Specimens of arsenopyrite were found on one of the old dumps in the workings on the hill south of the mill. The arsenopyrite is said to occur in a different vein from that which yielded most of the cassiterite. In a specimen from the collection of Mr. F. L. Hess, arsenopyrite and light gray cassiterite occur together. The specimens collected by the writer show rather massive, slightly altered material associated with a little quartz. The arsenopyrite is said to carry considerable amounts of gold and silver. Hotchkiss ^a quotes the following assays:

	Silver (ounces)	Gold (ounces)	Assayer
1.	38	0.1	A. S. McCreath
2.		\$60	B. Sullivan
3.		5.5	Ledoux & Ricketts
4.	73.73	7.36	Frank A. Massie

Specimens of pyrite were found in a small heap close to that from which the specimens of arsenopyrite were obtained. The mineral is partly massive and partly crystalline, and is associated with glassy quartz similar to that found in the cassiterite-bearing veins. Minute grains of pyrite occur in a few of the specimens of altered rock near the veins and much of this rock is irregularly iron-stained, as if through the oxidation of pyrite.

Wolframite is associated with the cassiterite in the workings of vein No. 2 on the hill south of the mill. The following analysis^b of wolframite was made by Mr. J. G. Dinwiddie from material collected by Mr. Hess during a visit to the mine in 1913:

Analysis of Wolframite from Irish Creek, Va.

	Percent
WO ₃	74.56
FeO	15.19
MnO	3.84
CaO	4.10
MgO	0.41
(TaCb) ₂ O ₅ , etc.	0.96
	100.20

Associated with the wolframite is a very small amount of scheelite, which occurs in small patches and veinlets through the wolframite.^c The

^a Hotchkiss, J.: Silver and Gold in Virginia Tin Belt, The Virginias, vol. 4, p. 168, 1883. The Tin Ore of Virginia, The Virginias, vol. 5, p. 38, 1884.

^b Hess, F. L., and Schaller, W. T.: Colorado ferberite and the wolframite series: U. S. Geol. Survey Bull. 583, p. 30, 1914.

^c Loc. cit., p. 31 and Pl. XIV.

wolframite is later than the cassiterite of the same vein, for the crystals of cassiterite contain minute veinlets of wolframite, and crystal faces of cassiterite are found adjoining the wolframite. Although no tungsten minerals have been observed in the ore of vein No. 1, an analysis made by Ledoux & Company, of concentrates said to have been derived from ore of that vein, showed that they contained 0.42 per cent of tungstic acid (WO_3), so that wolframite is probably present in both groups of veins.

The quartz of the veins is glassy and is white to bluish gray in color. Under the microscope it has a cloudy appearance, due to the presence of numerous minute cavities. Individual quartz crystals can not be distinguished in the hand specimen, but under the microscope the vein is seen to be made up of xenomorphic grains having an average diameter of about 4 millimeters. The quartz grains show the peculiar feathery extinction common in vein quartz. Silicification of the wall-rock is confined to the immediate walls of the veins, and as far as observed not much quartz has migrated into the country rock.

Siderite is a common mineral of the quartz veins, but not much of it occurs in the wall-rock. Most of it is found close to the walls of the veins, but some occurs in the center of the veins. It is in part altered to porous limonite. The dark brown color of the siderite and its submetallic luster make it resemble the cassiterite, from which, however, it can readily be distinguished by its cleavage and its lower specific gravity.

Beryl is seen in considerable amount in a small quartz vein near the mill. Here it occurs in long, slender prisms from 2 to 5 centimeters in length and only about 2 millimeters in diameter, normal to the walls of the vein. Under the microscope the edges of the crystals of beryl are seen to be slightly fissured. These fissures are filled with quartz, which shows optical continuity with the larger crystals that form the mass of the vein, as if the beryl had been formed before the quartz solidified. Beryl occurs also in the altered wall-rock of this vein where it forms an aggregate with mica. Rare microscopic crystals of beryl appear in the altered rock that surrounds the other cassiterite-bearing veins.

Muscovite occurs both as a vein mineral and as the principal constituent of the altered granodiorite close to the veins. It is not at all prominent in the veins themselves, and where present occurs in small plates close to the wall. In the beryl-bearing vein, however, the quartz near the beryl crystals is flecked with muscovite. The altered granodiorite is composed largely of muscovite, which occurs both in small, unoriented platy crystals, and,

particularly near the veins, in short, stout prisms. Ulke^a mentions damourite as among the minerals in the tin deposits, but in the present investigation it has not been distinguished from muscovite.

Flourite and muscovite make up the greater part of the altered rock that borders the cassiterite-bearing veins, but fluorite does not occur as a vein mineral. Most of the fluorite is white and very fine-grained; only a few of the larger individuals show a purple tinge.

The tin-bearing veins are everywhere accompanied by a peculiar type of alteration of the adjoining granodiorite. The rock at some places immediately adjacent to the vein is almost completely silicified, but outside of a narrow zone little or no secondary quartz is found. Close to the vein the original rock is completely replaced by an aggregate of muscovite, colorless fluorite, and minor amounts of beryl, siderite, and cassiterite. Quartz and ilmenite are seen in some specimens but are apparently residual from the granodiorite. This alteration product resembles the so-called greisen that is found elsewhere in tin deposits, but, instead of being composed essentially of quartz and muscovite, it consists of fluorite and muscovite. The term greisen has therefore been avoided in this description. At a greater distance from the vein the alteration of the granodiorite is confined to partial replacement of the hypersthene by biotite and muscovite. The hypersthene appears to be the mineral most easily altered; next comes the plagioclase, and next the quartz, which remains almost unaffected. The zone of intense alteration ranges in width from a few inches to several feet, but everywhere, as far as could be observed, accompanies the tin-bearing veins. The granodiorite near the tin deposits does not contain the secondary epidote which is so prominent at other places.

The veins are probably not continuous for long distances, but as the exposures are poor it is impossible to say this with certainty. Vein No. 1, near the old mill, has been developed for about 200 feet eastward from the stream, and according to older reports had been exposed in prospect pits for about 1,000 feet. The old workings along the veins of the No. 2 workings, on the hill south of the mill, indicate development for not more than 500 feet. The veins elsewhere in the region do not appear to extend very far. The wide variation in the strike of the veins indicates the absence of a definite fissure system and is regarded as additional evidence that the veins are not persistent for long distances.

^a Loc. cit., p. 179.

THE WORKINGS.

Most of the early work of exploitation was done at two localities, one, called the No. 1 workings, on the east bank of the stream, about 500 feet southeast of the mill, and the other, called the No. 2 workings, on the hill south of the mill, about 1,200 feet from it. The old workings are now caved, and only here and there can any idea be gained as to the nature of the veins. Other veins, apparently of some promise, have been prospected

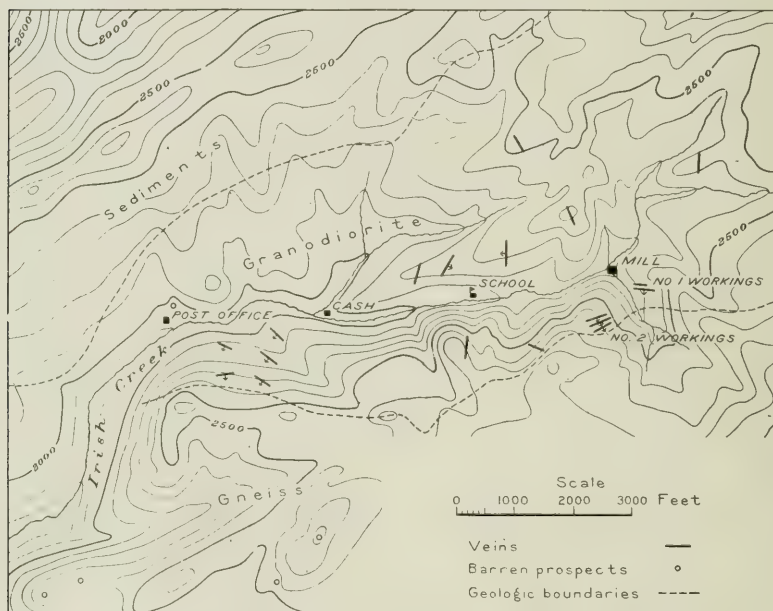


FIG. 2.—Sketch map of the Irish Creek district, showing the location of tin-bearing veins. Contour interval, 100 feet.

on the ridge north of the schoolhouse and on the hills north of the mill. No evidence of valuable mineralization was found in the other old prospects seen at several places in the region, though Winslow's report^a shows that the ore from two of these contains tin.

The vein near the mill has a westerly strike and dips steeply to the south. It has been followed by tunnel and open cut for about 200 feet eastward from the stream. The old workings show a maximum width of

^a Winslow, A.: Tin ore in Virginia, Eng. & Min. Jour., vol. 40, p. 320, 1885.

12 feet, which, however, undoubtedly includes both the vein and the altered granite. At the eastern end of the workings the vein has a width of from 1 to 3 inches and is bordered on either side by a narrow zone of altered granodiorite. A little cassiterite is seen in the quartz close to the walls of the vein, and microscopic grains of cassiterite occur in the altered wall-rock. According to Mr. Cash, the workings followed a vein of nearly pure cassiterite along the hanging wall. This vein ranged in thickness from a knife edge to about 2 inches, and here and there included pockets in which large crystals of cassiterite were found in vugs. The last company operating in the district is said to have confined its attention to the No. 1 workings, and probably most of the tin produced came from this vein.

About 100 feet north of the No. 1 workings a small open cut exposes a 3-inch quartz vein carrying a considerable amount of beryl in long, slender crystals and some muscovite in small plates. The granodiorite next to the vein is greatly altered, but the alteration here consists of replacement of the original rock by an aggregate of muscovite and beryl, rather than of muscovite and fluorite as in the other veins. No cassiterite was seen in the specimens from this vein.

A large pile of waste rock, about 75 feet south of the developed vein, is said to have been placed there to conceal the outcrop of a small vein that is exceedingly rich in cassiterite. Nothing was observed on the hill to the east which would confirm this.

The workings on the hill south of the mill, known as the No. 2 workings, were the site of the principal operations during the earlier part of the period of mining activity, but are now entirely caved. There are several small open cuts and shafts, two tunnels, probably of considerable extent, and one inclined shaft, which is said to have reached a depth of 60 feet. The position of these is shown on the accompanying sketch map (Fig. 3).

The most northerly of the veins of the No. 2 workings was prospected in a shaft on the point of the hill, about 1,200 feet S. 7° W. from the mill. The vein here shows about 3 feet of milk-white, glassy quartz with patches of limonite. No cassiterite was seen, but the adjoining granodiorite shows the characteristic alteration to an aggregate of muscovite and fluorite. The strike here is N. 57° E. and the dip is 57° S. E. The same vein has been exposed in an open cut about 300 feet east-southeast of the shaft. Here it is 8 feet wide, strikes N. 62 to 67° E. and dips 70° S. E. A smaller parallel vein lies 30 feet to the southwest. The granodiorite here is less altered, but between the two veins it is cut by a large number of quartz stringers. A short distance northeast of this cut the same vein out-

crops on the side of the hill. The vein could not be traced along its course in either direction beyond the shaft and open cut.

The principal development work appears to have been done on a vein that lies about 100 feet south of the one just described and that is nearly parallel to it. The easternmost exposure of this vein is in an open cut about 200 feet southwest of the shaft on the northern vein. In this cut bluish-

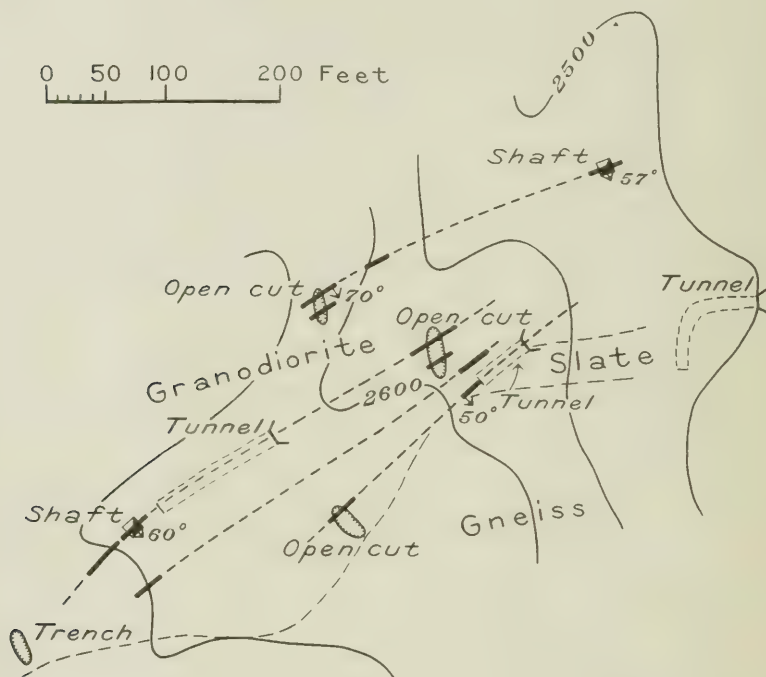


FIG. 3.—Sketch map of the No. 2 workings. Contour interval, 50 feet.

gray quartz and patches of limonite are exposed. The walls are too badly caved to show the width of the vein, but the workings probably cut several small veins. The granodiorite is less altered here than in the exposures farther southwest. Small diabase dikes appear to cut both granodiorite and quartz. The dump of a caved shaft a few feet to the southwest contains quartz and altered granodiorite, which indicate the presence of a parallel vein. About 120 feet southwest of the cut just described there is a caved tunnel that follows the vein for over 100 feet along the strike, which is here

S. 67° W. At the northwest end of this tunnel there is an old platform on which were found several fragments of high-grade ore that had apparently been hand sorted and selected for transportation. At the west end of the tunnel is a large inclined shaft, now caved, which followed the dip of the vein, here about 60° S. E. The vein strikes N. 47° E., and is about 5 feet wide at the collar of the shaft. The granodiorite here is intensely altered close to the walls. The shaft is said to have been 60 feet deep, with a drift from the bottom, and, according to local report, much of the best ore was obtained here. A large outcrop, 40 feet southwest of the shaft, exposes two veins of white quartz, 5 and 10 feet in width, between which lie 5 feet of altered granodiorite. About 30 feet to the southwest there is a small outcrop of quartz, apparently a continuation of the vein prospected in a small shaft to the northeast. A trench dug across the strike of the main vein, 80 feet southwest of the large outcrop, shows only fragments of gneiss and granodiorite, but this trench may not have reached bedrock.

A vein that lies a short distance south of the last was developed to some extent by shaft and drift, or tunnel. The workings are caved, but the drift apparently followed the vein for about 70 feet. At the southwest end of this drift a small vein of glassy quartz that strikes N. 47° E. and dips 50° S. E. is exposed. Along a part of the drift fragments of slate occur in the hanging wall of the vein. The specimens of arsenopyrite and pyrite already described were found near these workings and probably came from this vein. The same vein appears in a small open cut about 150 feet southeast of these workings. A large tunnel enters the hill at a point 200 feet west of the workings just described and may have been run to cross-cut the vein, though the caved surface indicates a sharp turn to the south. The dump contains granodiorite, gneiss, purple slate, a dark schist not seen on the surface, and a little quartz.

The other prospects seen in the district are too badly caved to afford any evidence as to the size or direction of the veins. The strikes shown on Winslow's map have therefore been used for all places that could be identified. Two veins have been prospected on the ridge north of the road, between the Cash house and the school. The work consists of pits and small tunnels. Winslow's map indicates that the western vein strikes N. 18° E., and that the eastern strikes N. 26° E. and dips 80° S. E. The dumps show altered granodiorite, a little quartz, and in places fragments of diabase.

Fragments of altered granodiorite, indicating the presence of an unprospected vein, were found on the crest of the ridge at a point 1,200 feet northeast of the schoolhouse. This vein is approximately in the position of

a vein shown on Winslow's map as striking north and dipping 40° W. About 1,000 feet farther east, on the summit of the ridge, a vein has been prospected by tunnel and shaft. The rock exposed shows granodiorite cut by small veinlets of limonite-bearing quartz, none over half an inch in diameter. No micaceous alteration product, such as elsewhere accompanies the tin-bearing veins, was found here. At a place near the crest of a ridge 1,500 feet northwest of the one just mentioned, and parallel to it, another vein, or possibly an extension of the same vein, has been prospected in a small tunnel and shaft. Here a small amount of white quartz, carrying mica and limonite, and probably a little cassiterite, together with intensely altered granodiorite, has been sorted and piled on the dump. The waste rock consists of less altered granodiorite cut by small veinlets of quartz. The direction of the tunnel is N. 38° W.

The only other notable prospect north of the creek is on a small ridge 2,500 feet northeast of the mill. Here a vein has been prospected by a large open cut about 100 feet long, which was carried northward across the crest of the ridge. The walls of the cut have caved and the rock is concealed except at its northern end, where there is a small exposure of granodiorite. The ore pile contains altered granodiorite, which is rich in muscovite and is cut by small, irregular veinlets of quartz. The quartz is white and glassy and contains small amounts of muscovite, particularly near the walls of the veins.

Winslow's map shows a group of five veins on the south side of the creek about 1,000 feet southwest of the Cash house. The veins strike to the west and northwest and dip at varying angles to the south and southwest. The middle vein is said by Winslow^a to be 3 feet wide, and ore from it yielded on assay 1.12 per cent of tin. The writer found an old shaft at this place but saw no evidence of valuable mineralization.

Winslow's map shows two other veins, with strikes of N. 12° E. and N. 74° W., on the south side of the creek between the group of five veins mentioned above and the No. 2 workings. Winslow^b states that the westernmost of these is a foot in width and assayed 0.63 per cent of tin.

PROBABLE TIN CONTENT OF THE ORE.

The ore bin of the mill is nearly full and considerable material that was mined as ore is piled near the mill. This material consists of granodiorite

^a Loc. cit., p. 320.

^b Loc. cit., p. 320.

more or less altered, and a very small amount of vein quartz, and it probably represents the grade of ore handled in the last stages of operation. According to local report the ore that showed visible cassiterite was not milled but was picked out and cobbled by hand. Samples of the material in the ore bin and in a pile of crushed ore on the vanner in the mill were taken by the writer, and were assayed by Ledoux & Company, New York. They contained 0.30 and 0.21 per cent of tin, respectively. A sample from a small pile of concentrates on the floor of the mill, also assayed by Ledoux & Company, contained 15.80 per cent of tin and 0.42 per cent of tungsten trioxide (WO_3). These concentrates are rather coarse and consist chiefly of quartz, ilmenite, siderite, muscovite, cassiterite, and minor amounts of pyrite, fluorite, and unidentified nonmetallic minerals. The ilmenite and siderite were readily removed by an electromagnet. Better gravity concentration would have increased the tin content by removing the quartz and muscovite.

These assays do not in themselves encourage any attempt to develop workable tin deposits in the Irish Creek district, but the samples assayed represent material left in the mill when the mine was abandoned after the high-grade ore had been already picked out. The ore shoots were doubtless small, and after those first discovered were worked out, low-grade material was probably mined without much regard to its tin content. The old workings appear to have been unsystematic "gophering" rather than operations following a definite plan of development.

A clue to the tenor of the ore mined is given by Benedict^a in a record of test runs of the mill, which shows that 90 tons assaying 3.44 per cent of tin gave concentrates assaying 43.44 per cent, 75 tons assaying 3.28 per cent of tin gave concentrates assaying 40.40 per cent, and 125 tons assaying 3.28 per cent of tin gave concentrates assaying 45.07 per cent.

It is possible, however, that the ore selected for these runs was above the average grade. Winslow's^b report gives assays of ore from two veins, neither of them worked later, showing a tin content of 0.63 and 1.12 per cent.

A report by Hotchkiss^c gives the results of a large number of assays, but as it contains no map the places at which the ore was found can not easily be identified. Most of the samples taken from the No. 1 and No. 2 workings, however, contained a high percentage of tin. Other old reports

^a Mineral Industry, 1892, vol. 1, pp. 455-456, 1893.

^b Winslow, A.: Tin ore in Virginia, Eng. and Min. Jour., vol. 40, p. 320. 1885.

^c Min. Res. of the U. S. 1885, Tin, pp. 371-376, 1886.

show workable ore, particularly in the No. 1 workings. If the assays quoted in these reports are at all representative the district should be reëxamined carefully, in view of the present urgent demand for tin.

According to Winslow,^a cassiterite has been found along the east side of the crest of the Blue Ridge from the James River Gap to the northern boundary of Rockbridge County. Although, as far as known, prospecting has been confined to the headwaters of Irish Creek, workable tin veins may be discovered elsewhere in the vicinity, for the same type of hypersthene granodiorite is found throughout the region.

The district appears to offer little chance for successful placer mining. Irish Creek contains a few stretches of bouldery gravel, particularly a short distance below the post-office and near the mouth of Nettle Creek. These might be available for sluicing if the tin content should be sufficient to justify it. Sands from Irish Creek and neighboring small creeks were panned and some of them yielded a little cassiterite, but not enough to encourage the hope of finding workable placers. The presence of small, isolated areas of sediments near the veins appears to show that the veins have undergone very slight erosion since Cambrian time and that only a little cassiterite has found its way into the streams. The concentrates from panning consist of ilmenite and epidote, and some yielded a few grains of cassiterite.

The Irish Creek district is 12 miles from the railroad, and the long wagon haul would necessarily add to the expense of mining. At present, however, a logging railroad is being built up Irish Creek to a point near Irish Creek post-office, and this would make transportation somewhat easier. Sufficient water for concentration is available in Irish Creek. There is also a good supply of firewood near the tin deposit.

CONCLUSION.

In conclusion it may be said that the district offers some hope of reward for systematic development of the discovered veins, and a possibility that prospecting in the area of hypersthene granodiorite along the Blue Ridge in this vicinity may uncover other deposits. The best indication of a possible tin deposit appears to be the presence of the greisen-like alteration product of the granodiorite, which everywhere appears to accompany the tin-bearing veins. Where float of fragments of this muscovite-fluorite rock is found on the hillsides it should be followed up carefully. Panning of the

^a Loc. cit., p. 320, 1885.

soil of the hillside may also lead to new discoveries. Areas in which the granodiorite has suffered extensive epidotization will probably be less favorable than those in which the rock is unaltered.

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TEST FOR CASSITERITE.

The following simple test for cassiterite, given by Hess,^a will be useful in prospecting:

"The simplest and easiest test for cassiterite is to place a fragment of the mineral in dilute hydrochloric or sulphuric acid with granulated, shot, or sheet zinc. The zinc and the acid rapidly evolve hydrogen, which takes the oxygen from the mineral and leaves a coating of tin on the fragment tested. Granulated zinc is the best to use, as its small particles can be made to touch the specimens at many points and thus bring more of the hydrogen in contact with the molecules of tin-oxide. The reaction is $4H + SnO_2 = Sn + 2H_2O$.

"The metallic coating has a dull gray, somewhat leaden appearance, but it may be made lustrous by rubbing with a soft cloth or with the hand. If the hand is used, the characteristic odor given off when tin is rubbed on the flesh may be noted."

A variation of this test was used to determine the presence of small amounts of finely divided cassiterite in concentrated stream sand, in which the cassiterite could not be distinguished with the eye. Place the sand on a small saucer-shaped piece of sheet zinc, immerse it for a few seconds in dilute hydrochloric acid, then wash off the acid. The grains of cassiterite will assume a characteristic metallic appearance and can readily be distinguished from the surrounding material. Care must be taken that the sand is spread out so evenly that all the grains are in contact with the zinc. The acid should remain on the sand for a short time only; if left too long the soluble silicates in the sand will leave a deposit of gelatinous silica on the zinc, which will make the separation of the grains of cassiterite difficult.

SUMMARY.

The existence of deposits of cassiterite in the Irish Creek district of Virginia has been known for many years, and between 1883 and 1893 attempts were made to exploit them, but as far as is known, however, very little tin was produced.

^a Hess, F. L. Tin in 1915: Min. Res. of the United States for 1915, p. 817, 1916.

The occurrence of the cassiterite in this district is unusual in that the veins are associated with a granitic rock of a peculiar type, a hypersthene granodiorite, rather than a potassic granite, which is the usual associate of tin deposits. This granodiorite and the accompanying veins are believed to be of pre-Cambrian age, but younger than the granitic gneisses of the region. The stanniferous veins were probably formed soon after the intrusion of the hypersthene granodiorite.

The cassiterite occurs in quartz veins, which do not appear to be continuous for long distances, and their tin content is probably very irregular. Some specimens of high-grade ore were found, however, and such early records as are available indicate that the known veins may be workable, and new veins may perhaps be discovered. Placer mining will probably not be profitable.



